LCROSS

- Our next mission to the surface of the Moon.
- Developed and managed by NASA Ames Research Center in partnership with Northrop Grumman.
- Goal: to test whether or not water ice deposits exist on the Moon.

Why look for water?

- Humans exploring the Moon will need water:
  - Option 1: Carry it there.
  - Option 2: Use water that may be there already!
- Carrying water to the Moon will be expensive!
- Learning to "Live off the land" would make human lunar exploration easier.

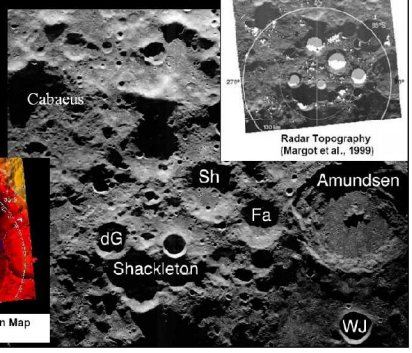
Early Evidence for Water

Clementine

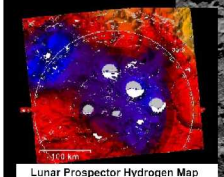
Lunar Prospector

Two previous missions, Clementine (1994) and Lunar Prospector (1999) gave us preliminary evidence that there may be deposits of water ice at the lunar poles.

Where will we look?



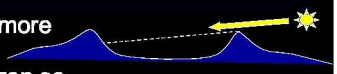
Radar Topography
(Margot et al., 1999)



Lunar Prospector Hydrogen Map
(Maurice et la., 2003)

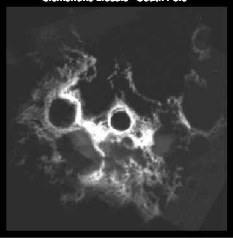
How could there be water at the lunar poles?

The Sun never rises more than a few degrees above the polar horizon so the crater floors are in permanent shadow.



The crater floors are very cold with temperatures < -200° C (-328° F), so water molecules move very slowly and are trapped for billions of years.

Clementine Mosaic - South Pole



Where could water ice come from?

Over the history of the Moon, when comets or asteroids impact the Moon's surface, they briefly produce a very thin atmosphere that quickly escapes into space.

Any water vapor that enters permanently shadowed craters could condense and concentrate there.

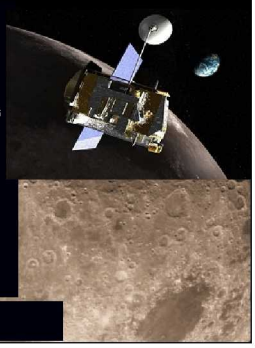
How can we look for water?

Lunar Reconnaissance Orbiter
LRO

Lunar Crater Observation and Sensing Satellite
LCROSS

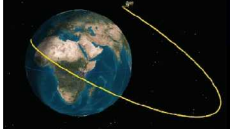
Lunar Reconnaissance Orbiter

- LROC – image and map the lunar surface in unprecedented detail
- LOLA – provide precise global lunar topographic data through laser altimetry
- LAMP – remotely probe the Moon's permanently shadowed regions
- CRaTER - characterize the global lunar radiation environment
- DIVINER – measure lunar surface temperatures
- LEND – measure neutron flux to study hydrogen concentrations in lunar soil

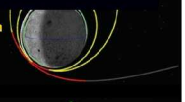


LRO Mission Overview

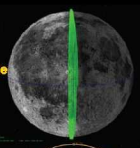
- On-board propulsion system used to capture at the Moon, insert into and maintain 50 km mean altitude circular polar reconnaissance orbit
- 1 year exploration mission followed by handover to NASA science mission directorate



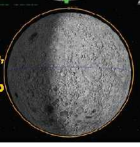
Minimum Energy Lunar Transfer



Lunar Orbit Insertion Sequence

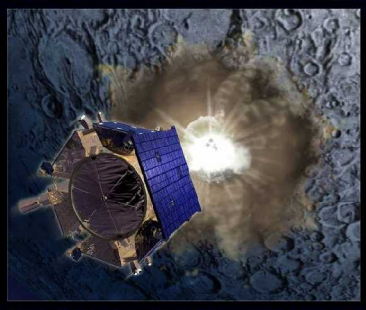


Polar Mapping Phase, 50 km Altitude Circular Orbit, At least 1 Year



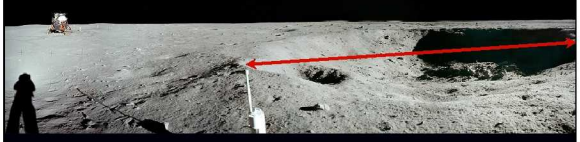
Commissioning Phase, 30 x 216 km Altitude Quasi-Frozen Orbit, Up to 60 Days

LCROSS Mission Concept



- Impact the Moon at 2.5 km/sec with a Centaur upper stage and create an ejecta cloud that may reach over 10 km about the surface
- Observe the impact and ejecta with instruments that can detect water

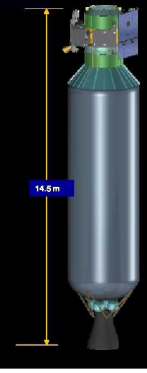
Excavating with 6.5-7 billion Joules

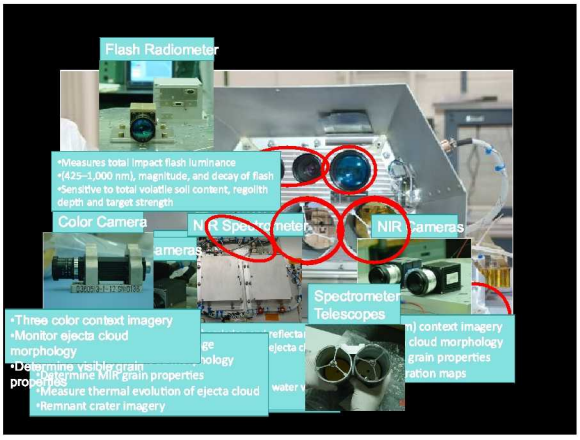


- About equal to 1.5 tons of TNT
- Minimum of 200 tons lunar rock and soil will be excavated
- Crater estimated to have ~20-25 m diameter and ~3 depth
- Similar in size to East Crater at Apollo 11 landing site

LCROSS Mission System

- **Shepherding Spacecraft:** guides and aims the Centaur to its target and carries all of the critical instrumentation.
- **Centaur Upper Stage:** provides the thrust to get us from Earth orbit to the Moon and will then be used as an impactor.

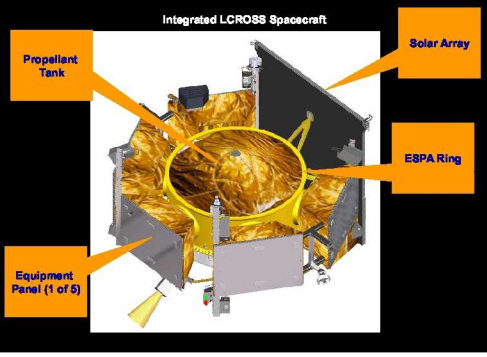




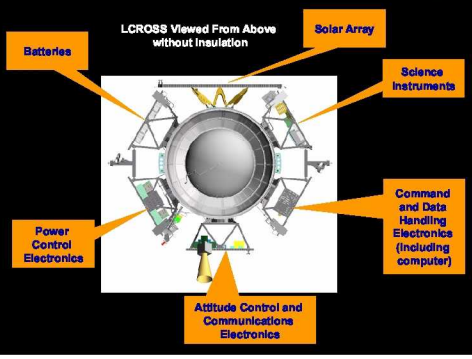
Save $ and Time by Using an Existing Structure Designed to Carry Heavy Payloads During Launch

But how do you make a spacecraft out of something that looks like a sewer pipe?

Answer: Put Equipment Around the Rim and Tank in the Middle

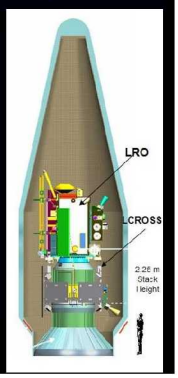


Different Panels Perform Different Functions



Scheduled Launch: June 17, 2009

- Both LCROSS and LRO will share space aboard an Atlas V launch vehicle.
- Launch will occur at Cape Canaveral.



Launch Vehicle

- We will use the Atlas V Launch Vehicle.
- This is the latest version in the Atlas family of boosters.
- Earlier versions of Atlas boosters were used for manned Mercury missions 1962-63.
- Atlas V has become a mainstay of U.S. satellite launches.
- NASA has used Atlas V to launch MRO to Mars in 2004 and New Horizons to Pluto and the Kuiper Belt in 2006.

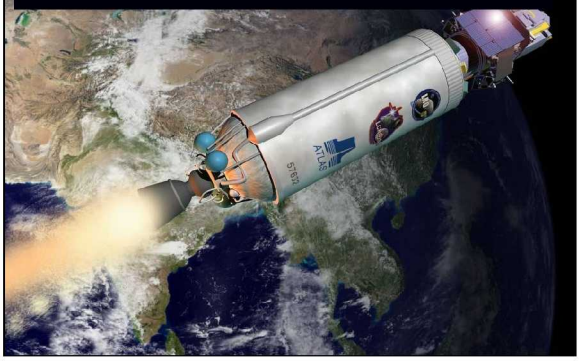
Launch Site

- We will launch from Space Launch Complex 41 (SLC-41) at Cape Canaveral.
- Historic site where many previous missions launched:
- Helios probes to the Sun
- Viking probes to Mars
- Voyager planetary flyby and deep space probes
- Mars Reconnaissance Orbiter
- New Horizons spacecraft to Pluto and Kuiper Belt

When?

- LRO/LCROSS scheduled for June 17 launch.
- This will lead to impact on October 8 for LCROSS.
- Impact will target the South Pole region of the Moon.

Centaur-LCROSS-LRO at TLI

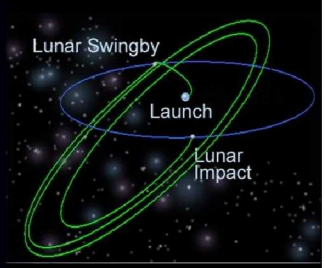


LRO Separation

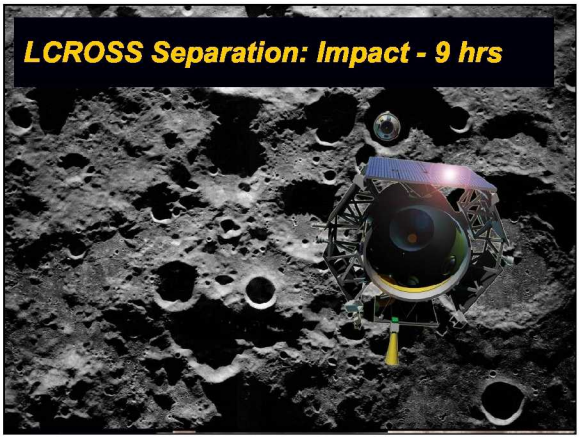
LCROSS Lunar Flyby: L + 5 days

LCROSS Trajectory: The Long and Winding Road

- Flyby transitions to Lunar Gravity Assist Lunar Return Orbits (LGALRO).
- 3 LGALRO orbits about Earth (~36 day period).
- Long transit also provides time to vent any remaining fuel from Centaur.

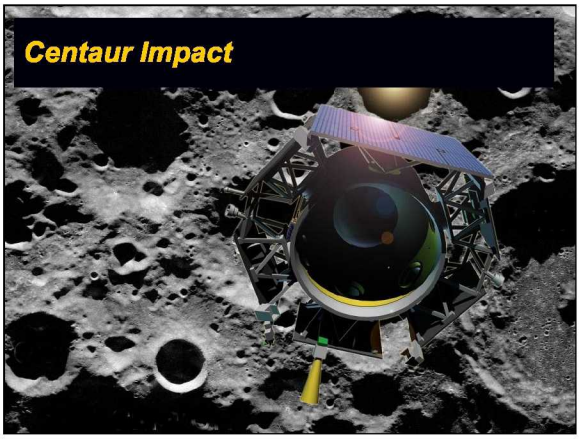


LCROSS Separation: Impact - 9 hrs



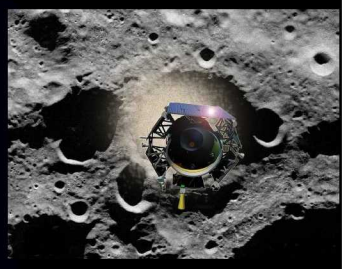
Centaur Impact

Centaur Impact



Into the Plume

- During the next 4 minutes, the Shepherding Spacecraft descends into the debris plume, measures its composition, and transmits this information back to Earth.
- The Shepherding Spacecraft then ends its mission with a second impact on the Moon.



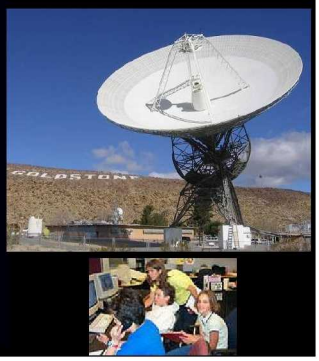
Impact Observation Campaign

Public and Student Observation

Amateurs and students with 10 to 12-inch telescopes may be able to observe and image the impact plume, and participate in the mission science.

Student Telemetry Program

- GAVRT – Goldstone Apple Valley Radio Telescope run by Lewis Center for Educational Research.
- K-12 classrooms across the country and around the world will control the 34-meter DSS-13 dish.
- Students will help track and monitor spacecraft status and velocity during flight.



Timing is everything!

- LCROSS mission in 2009 occurs during the International Year of Astronomy — 400 years since Galileo first pointed his telescope at the sky.
- The mission also takes place during the 40th anniversary of Apollo XI's first landing astronauts on the Moon.

www.nasa.gov/lcross